The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A device for measuring the relative displacement between two members, the device comprising:

a scale having a scale grating pattern formed along a measuring axis direction; and

a fiber optic readhead arrangement positionable to provide an operable image of the scale grating pattern, the fiber optic readhead arrangement comprising:

a housing element;

a lens; and

a plurality of fiber-optic receiver channels, each respective fiber-optic receiver channel comprising:

a respective receiver channel spatial phase mask portion having a respective spatial phase and having its light-blocking elements arranged at a pitch that is operable for spatially filtering the operable image of the scale grating pattern, the respective receiver channel spatial phase mask portion generally located at a nominal receiver plane that is operable for spatially filtering the operable image of the scale grating pattern; and

at least one respective receiver channel optical fiber having an input end that receives a respective receiver channel optical signal light;

wherein:

the respective receiver channel optical signal light received by the at least one respective receiver channel optical fiber comprises optical signal light collected through the respective receiver channel spatial phase mask portion over a respective collected light area having a collected light area dimension along the measuring axis direction that is at least one full period of the respective receiver channel spatial phase mask portion;

when the readhead is operably positioned relative to the scale grating pattern at least first and second respective channels of the plurality of fiber-optic receiver channels spatially filter their respective portions of the operable image of the scale grating pattern at the nominal receiver plane to provide at least first and second respective receiver channel optical signals having at least first and second respective signal phases; and

the device outputs the at least first and second respective receiver channel optical signals along respective optical fibers to provide relative displacement measurement information in the form of a plurality of respective optical output signals, the respective optical output signals produced without the use of an electronic photodetector element.

2. The device of Claim 1, wherein the fiber optic readhead arrangement comprises a transparent mask substrate and each respective receiver channel spatial phase mask portion is fabricated on a surface of the transparent mask substrate with its light-blocking elements positioned along the measuring axis direction with respect to the light-blocking elements of the other receiver channel spatial phase mask portions in a manner that establishes desired relationships between the respective spatial phases of the respective receiver channel spatial phase mask portions.

3. The device of Claim 2, wherein the input end of each respective receiver channel optical fiber is nominally positioned against the corresponding respective receiver channel spatial phase mask portion on the surface of the transparent mask substrate.

4. The device of Claim 1, wherein:

the fiber optic readhead arrangement has an optical axis;

each fiber-optic receiver channel has a respective nominal light-carrying area corresponding to an aggregate light-carrying core area of the at least one respective receiver channel optical fiber, the respective nominal light-carrying area proximate to the input end of the at least one respective receiver channel optical fiber having a respective nominal centroid; and

at least three respective fiber-optic receiver channels of the plurality of fiber-optic receiver channels each have a respective nominal centroid that is separated from the optical axis by a nominal respective location radius that is approximately the same for each of the at least three respective fiber-optic receiver channels.

5. The device of Claim 4, wherein:

a central optical fiber is positioned approximately concentrically with the optical axis, at least proximate to an end of the central optical fiber;

the central optical fiber comprises one of a) a source optical fiber that emits a respective radiation from a light-carrying core area at the end of the source optical fiber and b) a dummy fiber; and

the at least three respective fiber-optic receiver channels are positioned substantially against the central fiber at least proximate to the input ends of the respective receiver channel optical fibers and proximate to the end of the central optical fiber.

6. The device of Claim 1, wherein the plurality fiber-optic receiver channels comprise at least 2N respective fiber-optic receiver channels arranged in an arrangement of N operable pairs, where N is an integer equal to at least 2, each operable pair comprising two respective fiber-optic receiver channels arranged on opposite sides of a center of the arrangement of N operable pairs, wherein the two respective spatial phase mask portions corresponding to those two respective fiber-optic receiver channels have one of a) the same spatial phase and b) spatial phases that nominally differ by 180 degrees.

7. The device of Claim 1, wherein at least each collected light area and each input end are positioned entirely within a cylindrical volume having an axis perpendicular to the nominal receiver plane and having a cylinder radius that is at most 3 millimeters.

8. The device of Claim 7, wherein the cylinder radius containing at least each collected light area and input end is at most 2.0 millimeters.

9. The device of Claim 8, wherein the cylinder radius containing at least each collected light area and input end is at most 1.25 millimeters.

10. The device of Claim 7, wherein the respective collected light area is at least partially determined by at least one of a) an aggregate light-carrying core area proximate to the input end of the corresponding at least one respective receiver channel optical fiber, b) a light receiving area of a miniature lens positioned proximate to the respective receiver channel spatial phase mask portion and proximate to the input end of the at least one respective receiver channel optical fiber and c) a limiting aperture feature of the respective receiver channel spatial phase mask portion.

11. The device of Claim 1, wherein the housing element surrounds the other elements of the fiber optic readhead arrangement, the housing element has a relatively longer outer dimension in a length direction parallel to the axis of the optical fibers and relatively narrower outer dimensions in directions perpendicular to the axis of the optical fibers over at least a portion of its length, and the fiber optic readhead arrangement is constructed such that at least a portion of the length of the housing element can be inserted into a bore having a dimension perpendicular to its central axis that is at least as small as 5.0 millimeters.

12. The device of Claim 11, wherein at least a portion of the length of the housing element can be inserted into a bore having a dimension perpendicular to its central axis that is at least as small as 2.5 millimeters.

13. The device of Claim 12, wherein the fiber optic readhead arrangement is assembled into an orientation-maintaining connector that is mechanically interchangeable with at least one standard commercially-available polarization-maintaining optical fiber connector.

14. The device of Claim 1, wherein the fiber optic readhead arrangement has an optical axis and the fiber optic readhead arrangement further comprises a limiting aperture located along the optical axis between the imaging lens and the plurality of fiber-optic receiver channels.

15. The device of Claim 14, wherein the limiting aperture located along the optical axis is spaced apart from an effective plane of the imaging lens by a distance that is at least approximately the same as a focal distance of the imaging lens.

16. The device of Claim 14, wherein the limiting aperture has a limiting aperture dimension such that when the readhead is operably positioned relative to the scale grating pattern the operable image of the scale grating pattern generally located at the nominal receiver plane is blurred to an extent at least partially determined by the limiting aperture dimension.

17. The device of Claim 16, wherein the limiting aperture is circular and has a limiting aperture dimension that is a diameter of at least 100 microns and at most 500 microns

18. The device of Claim 17, wherein the limiting aperture is circular and has a limiting aperture dimension that is a diameter of at least 150 microns and at most 400 microns.

19. The device of Claim 16, wherein when there is relative displacement between the fiber optic readhead arrangement and scale grating pattern along the measuring axis direction, each respective optical output signal comprises a sinusoidal function of the relative displacement, and each such sinusoidal function varies from an ideal sinusoidal function by at most 1/16 of the peak-to-peak variation of each such sinusoidal function.

20. The device of Claim 19, wherein each such sinusoidal function varies from an ideal sinusoidal function by at most 1/32 of the peak-to-peak variation of each such sinusoidal function.

21. The device of Claim 1, wherein the fiber optic readhead arrangement is located on a first side of the scale grating pattern, the scale grating pattern includes transparent elements that transmit transmitted light arising on a second side of the scale grating pattern, and the operable image arises from transmitted light that enters the imaging lens.

22. The device of Claim 1, wherein the fiber optic readhead arrangement is located entirely on a first side of the scale grating pattern, the scale grating pattern includes reflective elements that are at least partially reflective and that reflect reflected light arising on the first side of the scale grating pattern, and the operable image arises from reflected light that enters the imaging lens.

23. The device of Claim 22, wherein the fiber optic readhead arrangement comprises at least one respective source of light, the light is emitted from the fiber optic readhead arrangement to illuminate the scale grating pattern, and at least some of the

reflected light arising on the first side of the scale grating pattern comprises reflected light that is emitted from the fiber optic readhead arrangement.

24. The device of Claim 23, wherein the at least one respective source of light comprises at least one respective receiver channel optical fiber end, the light is emitted from the fiber optic readhead arrangement through the imaging lens, and the light is input at a remote end of the at least one respective receiver channel optical fiber through at least one optical device that is operable to input the light to the remote end and is further operable to receive the respective optical output signal at the remote end and output the respective optical output signal along a path to a remote photodetector.

25. The device of Claim 24, wherein the at least one optical device that is operable to input the light to the remote end and is further operable to receive the respective optical output signal at the remote end comprises one of a beamsplitter and a circulator.

26. The device of Claim 23, wherein the light is emitted from the fiber optic readhead arrangement at a plurality of locations included in an annular region generally surrounding the imaging lens.

27. The device of Claim 26, wherein the plurality of locations are generally arranged in an arrangement that is axisymmetric with respect to an optical axis of the fiber optic readhead arrangement.

28. The device of Claim 26, wherein the fiber optic readhead arrangement comprises at least one light deflecting element positioned in the annular region generally surrounding the imaging lens and each at least one light deflecting element tends to deflect the light that is emitted from the fiber optic readhead arrangement toward an optical axis of the fiber optic readhead arrangement.

29. The device of Claim 26, wherein the fiber optic readhead arrangement comprises an element that at least partially diffuses the light that is emitted from the fiber optic readhead arrangement.

30. The device of Claim 26, wherein the plurality of locations correspond to a plurality of respective sources of light, each respective source of light comprising one of a) an electronic solid-state light source element, at least a portion of the solid-state light source element generating the light, and b) an output end of a source optical fiber, the source optical fiber connectable to a remote light source that generates the light.

31. The device of Claim 26, wherein the fiber optic readhead arrangement has an optical axis and the fiber optic readhead arrangement further comprises a limiting aperture located along the optical axis between the imaging lens and the plurality of fiber-optic receiver channels, the limiting aperture spaced apart from an effective plane of the imaging lens by a distance that is at least approximately the same as a focal distance of the imaging lens.

32. The device of Claim 31, wherein the light is emitted from the fiber optic readhead arrangement in a spatially-continuous distribution around the annular region generally surrounding the imaging lens.

33. The device of Claim 32, the fiber optic readhead arrangement comprising:

an optical element positioned along the optical axis, the optical element operable to input a light beam and output a diverging annular ring of light, the optical element comprising one of a) an axicon lens and b) a diffractive optical element;

an annular light deflecting element positioned in the annular region generally surrounding the imaging lens, the annular light deflecting element tending to deflect the light that is emitted from the fiber optic readhead arrangement toward the optical axis; and

the at least one respective source of light comprising an output end of a source optical fiber, the source optical fiber connectable to a remote light source that generates the light, the output end of the source optical fiber located along the optical axis and proximate to the nominal receiver plane,

wherein:

light output from the output end of the source optical fiber is received by the optical element, the optical element outputs a diverging annular ring of light, the diverging annular ring of light follows a path that generally surrounds the limiting

aperture and the imaging lens, the diverging annular ring of light enters the annular light deflecting element and is emitted from the fiber optic readhead arrangement in the spatially-continuous distribution around the annular region generally surrounding the imaging lens.

34. The device of Claim 33, the fiber optic readhead arrangement comprising a first optical baffle positioned generally surrounding the diverging annular ring of light and generally surrounding a diverging scale image light between the limiting aperture and the nominal receiving plane.

35. The device of Claim 34, the fiber optic readhead arrangement comprising a second optical baffle positioned generally inside the diverging annular ring of light and generally surrounding the diverging scale image light between the limiting aperture and the nominal receiving plane.

36. The device of Claim 1, wherein each respective collected light area has a collected light area dimension along the measuring axis direction that is at least three full periods of the respective receiver channel spatial phase mask portion.

37. The device of Claim 36, wherein each respective collected light area has a collected light area dimension along the measuring axis direction that is at least six full periods of the respective receiver channel spatial phase mask portion.

38. The device of Claim 1, further comprising a reflective surface, wherein:

the fiber optic readhead arrangement has an optical axis and the reflective surface is arranged at a location along the optical axis between the imaging lens and the scale grating pattern such that the reflective surface effectively deflects the optical axis by approximately 90 degrees; and

the fiber optic readhead arrangement and reflective surface are arranged relative to the scale grating pattern such that the nominal receiver plane and the operable image of the scale grating pattern are nominally perpendicular to the plane of the scale grating pattern.

39. The device of Claim 1, wherein the scale comprises one of a) a generally planar member wherein the scale grating pattern is formed along a measuring axis direction that follows a straight line on the planar member, b) a generally planar disk-like member wherein the scale grating pattern is formed along a measuring axis direction that follows a circular path on the disk-like member, c) a generally cylindrical member wherein the scale grating pattern is formed along a measuring axis direction that follows a circular path around the cylindrical member, and d) a generally linear tape-like member wherein the scale grating pattern is formed along a measuring axis direction that follows a relatively longer axis of the tape-like member.

40. The device of Claim 1, wherein the fiber optic readhead arrangement is in a transmissive configuration such that the operable image arises from transmitted light.

41. A method for operating a device for measuring the relative displacement between two members, the device comprising:

a fiber optic readhead arrangement positionable to provide an operable image of a scale grating pattern, the fiber optic readhead arrangement comprising:

a housing element;

an imaging lens;

a transparent mask substrate; and

a plurality of fiber-optic receiver channels, each respective fiber-optic receiver channel comprising:

a respective receiver channel spatial phase mask portion having a respective spatial phase and having its light-blocking elements arranged at a pitch that is operable for spatially filtering the operable image of the scale grating pattern, the respective receiver channel spatial phase mask portion generally located at a nominal receiver plane that is operable for spatially filtering the operable image of the scale grating pattern; and

at least one respective receiver channel optical fiber having an input end that receives a respective receiver channel optical signal light;

wherein:

each respective receiver channel spatial phase mask portion is fabricated on a surface of the transparent mask substrate with its light-blocking elements positioned

along the measuring axis direction with respect to the light-blocking elements of the other receiver channel spatial phase mask portions in a manner that establishes desired relationships between the respective spatial phases of the respective receiver channel spatial phase mask portions;

the respective receiver channel optical signal light received by the at least one respective receiver channel optical fiber comprises light arising from the scale grating pattern and collected through the respective receiver channel spatial phase mask portion over a respective collected light area having a collected light area dimension along the measuring axis direction that is at least three full periods of the respective receiver channel spatial phase mask portion; and

at least each collected light area and each input end are positioned entirely within a cylindrical volume having an axis perpendicular to the nominal receiver plane and having a cylinder radius that is at most 5 millimeters;

the method comprising:

operably positioning the fiber optic readhead arrangement relative to the scale grating pattern;

inputting light arising from the scale grating pattern through the imaging lens to produce the operable image of the scale grating pattern at the nominal receiver plane;

receiving the operable image of the scale grating pattern at the nominal receiver plane with at least first and second respective channels of the plurality of fiber-optic receiver channels and spatially filtering respective portions of the operable image of the scale grating pattern to provide at least first and second respective receiver channel optical signals having at least first and second respective signal phases; and

outputting the at least first and second respective receiver channel optical signals along respective optical fibers to provide relative displacement measurement information in the form of a plurality of respective optical output signals, the respective optical output signals arising from spatially filtered scale light without the use of an electronic photodetector element.

42. The method of Claim 41, the fiber optic readhead arrangement further comprising a limiting aperture located along an optical axis between the imaging lens and the plurality of fiber-optic receiver channels, the limiting aperture spaced apart from an

effective plane of the imaging lens by a distance that is at least approximately the same as a focal distance of the imaging lens, wherein inputting light arising from the scale grating pattern through the imaging lens to produce the operable image of the scale grating pattern comprises inputting light arising from the scale grating pattern through the imaging lens and through the limiting aperture to produce the operable image of the scale grating pattern at the nominal receiver plane.

43. The method of Claim 41, wherein operably positioning the fiber optic readhead arrangement relative to the scale grating pattern comprises positioning the fiber optic readhead arrangement relative to the scale grating pattern such that the operable image of the scale grating pattern generally located at the nominal receiver plane is blurred to an extent such that when there is relative displacement between the fiber optic readhead arrangement and scale grating pattern along the measuring axis direction, each respective optical output signal comprises a sinusoidal function of the relative displacement, and each such sinusoidal function varies from an ideal sinusoidal function by at most 1/16 of the peak-to-peak variation of each such sinusoidal function.

44. The method of Claim 41, wherein the operably positioned fiber optic readhead arrangement is located entirely on a first side of the scale grating pattern, the scale grating pattern includes reflective elements that are at least partially reflective and that reflect reflected light arising on the first side of the scale grating pattern, and inputting light arising from the scale grating pattern through the imaging lens comprises inputting the reflected light arising on the first side of the scale grating pattern.

45. The device of Claim 44, the fiber optic readhead arrangement further comprising at least one respective source of light, the method further comprising emitting light from the fiber optic readhead arrangement to illuminate the scale grating pattern such that at least some of the reflected light arising on the first side of the scale grating pattern comprises reflected light that is emitted from the fiber optic readhead arrangement.